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# Determination of Probabilistic Voltage Stability Limit based on Schur's Inequality Indicator using Evolutionary Programming

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**ABSTRACT : In this research paper we are implementing Schur's inequality indicator for the voltage stability in the electrical power system. Many times under emergency state it is necessary to improve voltage stability by rescheduling the minimum number of control variables from implementation viewpoint. One way of achieving this is obtained by suitable choice of indicator and adequate load bus voltages. a reactive power planning incorporating voltage stability methodology has been developed addressing economic issues.**

***Key words: Voltage stability , Schur's inequality indicator , Reactive power,*** *EPANN*

## I. INTRODUCTION

Power companies are facing a major challenge in the maintaining of quality and security of power supply due to ever-increasing interconnections and loading in large power system networks. Economic constraint has forced the utilities to operate generators and transmission systems very near to maximum loadability point. Most of the modern power systems are facing the problem of maintaining the required bus voltages and have become voltage stability limited[1, 2]. Voltage stability is concerned with the ability of a power system to maintain acceptable bus voltage under normal conditions and after being subjected to a disturbance. The voltage stability margin is termed as distance to voltage collapse point from current operating point [3]. Adequate voltage stability margin must be maintained for a secure operation of a power system. Precisely voltage security has been defined as the ability of a system not only to operate stably but also remain stable following a contingency. It has been a standard practice to evaluate reliability indices (probabilistic approach) based on security analysis accounting correct ability in the planning of stages [4, 5].

Many corrective rescheduling algorithms have been developed for maintaining desired level of stability margin. There has been a trend to evaluate reliability indices based on voltage stability consideration. A few studies[6, 7, 8] have used static voltage stability limit for evaluating reliability indices.

## II. IMPORTANCE OF REACTIVE POWER

In the estimation of voltages and reactive power outputs and flows, the explicit consideration of reactive power limits is very important. Following a contingency, the voltage control devices (generators, synchronous condensers, tap changers, etc.) change their settings in accordance to the control logic. Whenever a device reaches a control limit, e.g., minimum tap ratio is reached at a transformer; the device cannot control the voltage. Ignoring this mechanism leads to significant estimation errors in voltage, reactive power generation and flows, since the latter depend heavily on voltage magnitudes.

## III. POWER FLOW BACKGROUND

Consider an N-bus power system characterized by the admittance matrix Y. The i, j element $Y_{ij}$ of Y is given by

$$Y_{ij} = -y_{ij},\ i \neq j \qquad (1)$$

$$Y_{ii} = \sum_j y_{ij} + y_{ig} \qquad (2)$$

Where $y_{ij}$ is the admittance of the line between buses i and j , and $y_{ig}$ is the ground admittance of bus i. The real and imaginary parts of each element $Y_{ij}$ of Y are denoted by $G_{ij}$ and $B_{ij}$, respectively, so that $Y_{ij} = G_{ij} + jB_{ij}$.We denote the total active power generation and the total active load at bus i by $P_x^g$ and $P_x^l$, respectively, and their reactive power counterparts by $Q_x^g$ and $Q_x^l$. The load terms $P_x^l$ and $Q_x^l$ are assumed to be fixed. The net power injections at bus i in terms of the load and generation are

$$P_i = P_i^g - P_i^l \qquad (3)$$

$$Q_i = Q_i^g - Q_i^l \qquad (4)$$

the net power injections at bus satisfy.

$$P_i = \sum_{j=1}^{N} V_i V_j [G_{ij} \cos(\theta_i - \theta_j) + B_{ij} \sin(\theta_i - \theta_j)] \quad (5)$$

$$Q_i = \sum_{j=1}^{N} V_i V_j [G_{ij} \sin(\theta_i - \theta_j) - B_{ij} \cos(\theta_i - \theta_j)] \quad (6)$$

where $\theta_i$ and $V_i$ are the bus i's voltage phase angle and magnitude, respectively. For each bus i, there are two equations, (5) and (6), and 4 variables, $\theta_i$, $V_i$, $P_i$, and $Q_i$. Thus, two variables are usually specified to obtain a solution. We assume there is one slack bus, which has specified $\theta_i$ and $V_i$; PQ buses have $P_i$, and $Q_i$ specified, and PV buses have $P_i$, and $V_i$ specified. Since the net reactive power at a PV bus is not specified, and PV buses have a flexible reactive power source/load, usually a generator. The reactive power produced or consumed by a generator is limited, and depends on the active power being produced. Assuming there is one generator at bus i, and denoting the upper and lower limits for the reactive power generation by $\overline{Q}_i^g$ and $P_i^g$ and $\underline{Q}_i^g(P_i^g)$, respectively, the reactive power output is constrained by

$$\underline{Q_i^g}(P_i^g) \leq Q_i^g \leq \overline{Q_i^g}(P_i^g) \quad (7)$$

Let $V_i^{sp}$ be the specified voltage at the PV bus i. Whenever $Q_i^g$ attains any of its limits, $Q_i^g$ is fixed and specified, and $V_i$ is not necessarily equal to $V_i^{sp}$. Under these circumstances, the bus i, although originally a PV bus, needs to be treated as a PQ bus. If , $Q_i^g = \overline{Q}_i^g(P_i^g)$, then $V_i \leq V_i^{sp}$, and we call the bus *max VAr constrained*. If $Q_i^g = \underline{Q}_i^g(P_i^g)$ and $V_i \geq V_i^{sp}$ we call the bus *min VAr constrained*. Their inclusion in the estimation methods, with the consideration of their limits, can be easily handled. The vector x is constructed with the voltage angles of the PV and PQ buses, and the voltage magnitudes of the PQ buses, and the $\overline{x}$ vector is constructed with the voltage angles and magnitudes of all buses. Let $\overline{x}$ be the vector of the PQ and PV buses' active power injections, and the PQ buses' reactive power injections, both as explicit functions of $\overline{x}$ [4, 5]. Let $f^{sp}$ be the vector with the specified values for $f(\overline{x})$. The power flow problem is to obtain $\overline{x}$ such that

$$f(\overline{x}) = f^{sp} \quad (8)$$

In the solution of the power flow problem, the Jacobian

$$J := \frac{\partial f(\ddot{x})}{\partial x} \quad (9)$$

is used. Let $\dot{f}(\dot{x})$ be the vector of the active and reactive power injections at all buses. The *full Jacobian J* is defined as

$$\dot{J} := \frac{\partial \dot{f}(\dot{x})}{\partial \dot{x}} \quad (10)$$

The power $S_{ij} = P_{ij} + jQ_{ij}$ flowing from bus on the line that connects buses i and j is given by

$$P_{ij} = V_i V_j [G_{ij} \cos(\theta_i - \theta_j) + B_{ij} \sin(\theta_i - \theta_j)] - V_i^2 (G_{ij} - g_{ijg}/2) \quad \ldots\ldots(11)$$

$$Q_{ij} = V_i V_j [G_{ij} \sin(\theta_i - \theta_j) - B_{ij} \cos(\theta_i - \theta_j)] - V_i^2 (B_{ij} - b_{ijg}/2) \quad \ldots.(12)$$

where $g_{ijg} + jb_{ijg}$ is the shunt admittance of the line between buses i and j in the $\pi$ model. Note that in general $P_{ij} \neq -P_{ji}$ and $Q_{ij} \neq -Q_{ji}$.

## IV. PROPOSED METHODOLOGY

**Schur's inequality** is given as follows [6]:

$$\lambda_{\max} \leq \sqrt{\sum_{ij} a_{ij}^2} \quad (13)$$

where,

$a_{ij}$ - $ij^{th}$ element of a given square matrix $[A]$

$\lambda_{\max}$ - greatest eigen value of the matrix.

Magnitude of greatest eigen value is less than or equal to square root of sum of square of each element of the matrix. Statement (13) is used to derive lower bound on the minimum eigen value of load flow Jacobian. Sensitivity matrix $[S]$ is given as follows:

$$[S] = [J]^{-1} \quad (14)$$

Now using inequality (4.1) upper bound on maximum eigen value of $[S]$ is given as follows:

$$S\lambda_{\max} \leq \sqrt{\sum_{ij} s_{ij}^2} \qquad (15)$$

$S\lambda_{\max}$ denotes maximum eigen value of $[S]$ and $s_{ij}$ is its element. It is known from matrix theory that:

$$J\lambda_{\min} = 1/(S\lambda_{\max}) \qquad (16)$$

where, $J\lambda_{\min}$ is the minimum eigen value of load flow Jacobian.

Using relation (15), inequality relation (16) can be written as:

$$J\lambda_{\min} \geq 1/(\sqrt{\sum_{ij} s_{ij}^2}) = \tau \qquad (17)$$

In fact, right hand side of eqn. (17) is lower bound on the minimum eigen value of load flow Jacobian and defined as a proximity indicator $(\tau)$. Under light loading condition the value of '$\tau$' is large and as system is stressed the value of proximity indicator ($\tau$) decreases and approach to zero as collapse point is reached. Further, as system is stressed the value of lower bound ($\tau$) approaches to minimum eigen value of load flow Jacobian. Magnitude of this proximity indicator reflects the distance to voltage collapse from the current operating point and has been used for voltage stability enhancement. The proximity indicator is used for predicting loadability margin[7]. Loadability margin is predicted using a quadratic expression as follows:

$$P_d = P_{d0} + \alpha.\tau^2 \qquad (18)$$

$P_{d0}$ is loadability limit.

At two load points $P_{d1}$ and $P_{d2}$ values, $\tau_1$ and $\tau_2$ were evaluated and then value of loadability limit is calculated as:

$$P_{d0} = (P_{d1}.\tau_2^2 - \tau_1^2.P_{d2})/(\tau_2^2 - \tau_1^2) \quad (19)$$

## V. EVALUATION OF PROBABILISTIC VOLTAGE STABILITY LIMIT USING EPANN

Instances obtained in previous section are used to train a multi-layer feed forward network. This network contains one input layer, one hidden layer and one output layer. The network is trained using back propagation algorithm [8]. Number of units in input layer equals to number of reactive power control variables and total number of load buses. Number of unit in output layer is one, which gives output as voltage stability limit. Further the neurons in the hidden layer are assumed to be sigmoidal. Neuron in output layer is assumed to be non-sigmoidal (linear). Network equations of Fig-1 are written as follows:

$$Y = \sum_{j=1}^{m} W_{jo} O_j \qquad (20)$$

Output of $j^{th}$ neuron in hidden layer is as follows:

$$O_j = 1/(1+e^{-Net_j}),$$
$$j = 1,2,\ldots,n \qquad (21)$$

Where $Net_j$ is

$$Net_j = \sum_{j=1}^{n} W_{ij} X_i \quad j = 1,2,\ldots,n \qquad (22)$$

In above equations $W_{jo}$ are the weights connected between $j^{th}$ hidden neuron and output neuron. $W_{ij}$ are the weight connected between $i^{th}$ input node and $j^{th}$ hidden neuron. $X_i$ is input variable at $i^{th}$ node [9]. Weight change $\Delta W_{jo}$ are given by following formulae:

$$\Delta W_{jo} = \eta.\delta.O_j \qquad (23)$$

$$\delta = (T - Y) \qquad (24)$$

T and Y are target value and output of network respectively. $\eta$ is learning rate lies between (0, 1). Expression for weight change $\Delta W_{ij}$ (for hidden layer) is given as follows using Back propagation algorithm:

$$\Delta W_{ij} = \eta.\delta_j.X_i \qquad (25)$$

Where $\delta_j$ is error gradient and is given as follows:

$$\delta_j = \delta.W_{jo}.O_j(1-O_j)X_i \qquad (26)$$

$X_i$ is the element of input vector $[X]$,

Where,

$$[X]^T = [U_1, U_2, \ldots, U_{NC}, P_1, P_2, \ldots, P_{NB}]^T$$

following condition is satisfied.

$$E \leq \zeta(tolerance)$$

$$E = \sqrt{(1/2NT)\sum_{m=1}^{NT}(T^m - Y^m)^2} \qquad (27)$$

Where, $NT$-denotes total number of training instances, $T^{(m)}$ is the probability of voltage stability limit as calculated using simulation (Target value) for

$m^{th}$ training instance., $Y^{(m)}$ is the output of network for $m^{th}$ training instance.This completes training of BPA network [10].

In the second stage to make the computed output close to the target value an evolutionary computation (EC) algorithm is employed to determine the proper parameters of the network. EC algorithm is a probabilistic search procedure, which provides the global optimized solution, [11] if one has obtained a local optimum solution at the end of stage-2. The EC computation is explained in the following steps:

**Step-1**

Initial population is created with the help of solution obtained at the end of second stage. The initial parent trial vectors '$D_j$' i.e. $j = 1,2,3,...,M$ are randomly created by setting the elements of '$D_j$' is obtained as random variates from uniform distribution $U(\theta_j^v, \theta_j^{-v})$. Mean value of the distribution is the value of element obtained at the end of training of BPA network. $\underline{\theta}_{j,v}$ and $\overline{\theta}_{j,v}$ are the maximum and minimum value of weights or a specific center value of '$v^{th}$' element.

**Step-2**

Obtain a muted solution for each parent solution as follows:

$$D_j^{(i)} = D_j^{(i-1)} + N(0, \sigma_j^{(i-1)}) \qquad (28)$$

Where, $N(0, \sigma^{(i-1)})$ is a vector of random variates created using a zero-mean normal distribution and having $\sigma_j^{(i-1)}$ as standard deviation (known as mutation strength). Mutation strength $\sigma_j^{(i-1)}$ is obtained as:

$$\sigma_j^{(i-1)} = \zeta E_j^{(i-1)} \qquad (29)$$

$E_j^{(i-1)}$ is obtained for $D_j^{(i-1)}$ using relation (8). $\zeta$ is known as scaling factor, larger is the value of $E_j^{(i-1)}$ larger is mutation strength. In case of converged condition negligible mutation strength will be observed and this provides a termination criterion [12, 13].

**Step-3** Now one has 2M population size. Select M vectors, which give least values of error '$E_i$' as calculated using formulae (27).

**Step-4** Repeat step-2 and step-3 till no further improvement is obtained or a prespecified number of times [14].

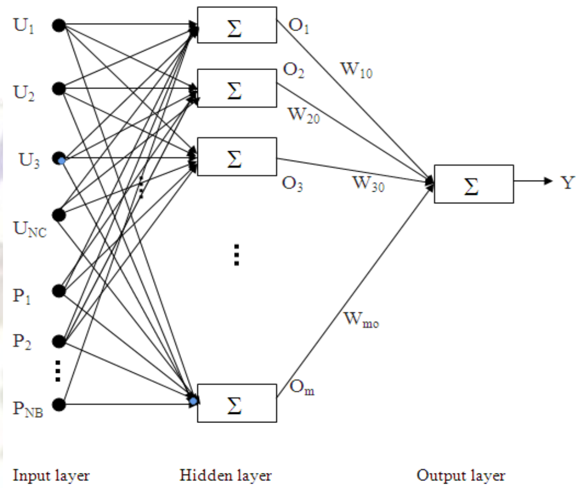


Fig. (1) Generalised diagram of EP based BPA for voltage stabi1lity limit calculations.

## VI. RESULTS

**TABLE.1 Load flow solution for 6-bus test system under base case condition.**

Total real load $P_d = 1.35\,pu$,

Total reactive load $Q_d = 0.32\,pu$,

Proximity indicator $\tau = 0.4251$

| Bus. No | Control variables | Control variables magnitudes (pu) | Load bus voltages | Load bus voltages magnitudes (pu) |
|---|---|---|---|---|
| 1 | $V_1$ | 1.0000 | $V_3$ | 0.8303 |
| 2 | $V_2$ | 0.9500 | $V_4$ | 0.8588 |
| 3 | $B_{SH4}$ | 0.0500 | $V_5$ | 0.7901 |
| 4 | $B_{SH6}$ | 0.0550 | $V_6$ | 0.8420 |
| 5 | $TAP_4$ | 1.0000 | | |
| 6 | $TAP_7$ | 1.0000 | | |

**TABLE-2 Sample training instances for training EPANN for 6-bus test system.**

| S. No. | $V_1$ (pu) | $V_2$ (pu) | $V_3$ (pu) | $P_d$ (pu) | Total Reactive Reserve obtatained by Continuation power flow | Total Reactive Reserve obtatained by EPANN | % Error |
|---|---|---|---|---|---|---|---|
| 1 | 0.9941 | 0.9751 | 1.0048 | 4.3615 | 1.7389 | 1.7545 | -0.35 |
| 2 | 0.9574 | 0.9954 | 1.0214 | 4.3892 | 1.5284 | 1.4997 | 1.87 |
| 3 | 0.9640 | 0.9809 | 0.9849 | 4.4133 | 1.4953 | 1.4879 | 0.49 |
| 4 | 0.9587 | 0.9889 | 0.9921 | 4.4298 | 1.5164 | 1.4918 | 1.62 |
| 5 | 0.9928 | 1.0262 | 0.9983 | 4.4482 | 1.4833 | 1.5062 | -1.54 |
| 6 | 1.0169 | 1.0463 | 0.9872 | 4.4539 | 1.5520 | 1.5783 | -1.69 |
| 7 | 1.0176 | 1.0374 | 0.9984 | 4.4619 | 1.5735 | 1.5611 | 0.79 |
| 8 | 1.0148 | 0.9718 | 0.9835 | 4.4679 | 1.4947 | 1.4827 | 0.80 |
| 9 | 1.0005 | 0.9937 | 1.0428 | 4.4781 | 1.6215 | 1.6382 | -1.03 |
| 10 | 0.9941 | 0.9751 | 1.0048 | 4.4845 | 1.4839 | 1.4748 | 0.61 |
| 11 | 1.0282 | 0.9750 | 0.9873 | 4.4893 | 1.7189 | 1.7445 | -1.48 |

**TABLE-3 Load flow solution for 14-bus test system under base case condition**

Total load $P_d = 6.6872\,pu$ ,

Proximity indicator $\tau = 0.2025$

| S. No. | $V_1$ (pu) | $V_2$ (pu) | $P_d$ (pu) | Total Reactive Reserve obtatained by Continuation power flow | Total Reactive Reserve obtatained by EPANN | % Error |
|---|---|---|---|---|---|---|
| 1 | 0.9635 | 0.9826 | 1.89665 | 1.3872 | 1.3692 | 1.30 |
| 2 | 0.9755 | 1.0013 | 1.90463 | 1.4140 | 1.3995 | 1.03 |
| 3 | 0.9755 | 0.9987 | 1.90768 | 1.3823 | 1.4083 | 1.88 |
| 4 | 0.9821 | 1.0004 | 1.90928 | 1.3975 | 1.3754 | 1.58 |
| 5 | 0.9865 | 0.9896 | 1.91018 | 1.3498 | 1.3587 | -0.66 |
| 6 | 0.9804 | 0.9861 | 1.91316 | 1.3882 | 1.3972 | -0.65 |
| 7 | 0.9972 | 0.9837 | 1.91365 | 1.4035 | 1.3915 | 0.85 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 8 | 0.9858 | 0.9769 | 1.91483 | 1.3718 | 1.3948 | 1.67 |
| 9 | 0.9845 | 1.0296 | 1.91573 | 1.4171 | 1.4003 | 1.19 |
| 10 | 0.9799 | 1.0008 | 1.91622 | 1.4005 | 1.3879 | 0.90 |
| 11 | 0.9947 | 0.9867 | 1.91851 | 1.3826 | 1.3592 | 1.69 |

**TABLE-4 Sample training instances for**
Training EPANN network for 14-bus test system

| S. No. | $V_1$ (pu) | $V_2$ (pu) | $V_3$ (pu) | $P_d$ (pu) | Total Reactive Reserve obtatained by Continuation power flow | Total Reactive Reserve obtatained by EPANN | % Error |
|---|---|---|---|---|---|---|---|
| 1 | 0.9941 | 0.9751 | 1.0048 | 4.3615 | 1.7389 | 1.7545 | -0.35 |
| 2 | 0.9574 | 0.9954 | 1.0214 | 4.3892 | 1.5284 | 1.4997 | 1.87 |
| 3 | 0.9640 | 0.9809 | 0.9849 | 4.4133 | 1.4953 | 1.4879 | 0.49 |
| 4 | 0.9587 | 0.9889 | 0.9921 | 4.4298 | 1.5164 | 1.4918 | 1.62 |
| 5 | 0.9928 | 1.0262 | 0.9983 | 4.4482 | 1.4833 | 1.5062 | -1.54 |
| 6 | 1.0169 | 1.0463 | 0.9872 | 4.4539 | 1.5520 | 1.5783 | -1.69 |
| 7 | 1.0176 | 1.0374 | 0.9984 | 4.4619 | 1.5735 | 1.5611 | 0.79 |
| 8 | 1.0148 | 0.9718 | 0.9835 | 4.4679 | 1.4947 | 1.4827 | 0.80 |
| 9 | 1.0005 | 0.9937 | 1.0428 | 4.4781 | 1.6215 | 1.6382 | -1.03 |
| 10 | 0.9941 | 0.9751 | 1.0048 | 4.4845 | 1.4839 | 1.4748 | 0.61 |
| 11 | 1.0282 | 0.9750 | 0.9873 | 4.4893 | 1.7189 | 1.7445 | -1.48 |

## VII. CONCLUSION

A technique for the management of reactive power reserve in order to improve static voltage stability has been presented. This has been achieved via a Evolutionary programming algorithm. Advantage of EP algorithm is that its mechanization is simple without much mathematical complexity. Moreover, global optimal solution is obtained and local optimal solution is avoided. Important about the methodology is that not only reactive reserve is optimized but inequality constraint on proximity indicator assures required static voltage stability margin. Network as well as source capabilities are important from voltage instability viewpoint. This is important aspect, which has been considered since, large reactive reserve available at a generator bus, which is not utilized in a load increased, scenario is not of great significance.

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## Reference:


1. P. Kundur, "Power system stability and control", New York: Mc Graw-Hill, 1994 *(Book)*.
2. W. Taylor, 'Power system voltage stability', New York: Mc Graw Hill, 1994 *(Book)*.
3. Canizares and F. L. Alvarado, "Point of collapse and continuation methods for large AC/DC systems", IEEE Trans. on Power Systems Vol. 8, No. 1, February 1993, pp. 1-8.
4. C. Jiang and C. Wang, 'Improved evolutionary programming with dynamic mutation and metropolis criteria for multi objective reactive power optimization', IEE Proc. GTD, Vol. 152, No. 2, March 2005, pp. 291-294.
5. F. Dong, B. H. Chowdhury, M. L. Crow, and L. Acar, 'Improving voltage stability by reactive power reserve management', IEEE Trans. on Power Systems, Vol. 20, No. 1, February 2005, pp. 338-345.
6. Zoran Kadelburg, Duˇsan Duki´ - c, Milivoje Luki´c and Ivan Mati´ " Inequalities of Karamata, Schur And Muirhead, And Some Application" The Teaching of Mathematics 2005, Vol. Viii, 1, PP. 31–45
7. L. D. Arya, D. K. Sakravdia and S. C. Choube, 'Development of a Proximity Indicator and its application for estimating maximum loadability point', Journal of Institution of Engineers (India), Vol. 82, September 2001, pp. 87-91.
8. R. Billinton and S. Aboreshaid, "Voltage stability Considerations in composite power system reliability evaluation", IEEE Trans. on Power Systems, Vol. 13, No. 2, May 1998, pp. 655-660.
9. L. D. Arya, S. C. Choube, and R. K. Saket, "Composite system reliability evaluation based on static voltage stability limit" JIE, Vol. 80, February 2000, pp. 133-139.
10. C. G. Melo, J. C. O. Mello, S. Granville, "The effects of voltage collapse problems in the reliability evaluation of composite systems", IEEE Trans. on Power Systems, Vol. 12, No. 1, Feb. 1997, pp. 480-487.
11. Anselmo B. Rodrigues and Maria G. Da Silva, "Probabilistic Assessment of Available Transfer Capability Based on Monte Carlo Method With Sequential Simulation", IEEE Trans. on Power Systems, Vol. 22, No. 1, February 2007, pp. 484-492.
12. R. A. Schlueter, "A voltage stability security assessment method", IEEE Trans. on Power Systems, Vol.13, No.4, November 1998, pp. 1423-1438.
13. Haesen, E.; Bastiaensen, C.; Driesen, J.; Belmans, R, "A Probabilistic Formulation of Load Margins in Power Systems With Stochastic Generation", IEEE Trans. on Power Systems, Volume 24, Issue 2, May 2009 Page(s):951 – 958
14. Zambroni De'souza, 'Discussion on some voltage collapse indices', Electric Power System Research, 2000, pp. 53-58.
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